Mathematical Modeling of Road Accidents in Metro Manila

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ABSTRACT

Road accidents in the Philippines have been identified as one of the causes of deaths in the country. It is one of the top five causes of morbidity and mortality in South-East Asian countries. Its socioeconomic repercussions are matter of great concern. These accidents have been categorized by Metropolitan Manila Development Authority (MMDA) as fatal, non-fatal and damage to property cases. This classification is based on the extent of damage to human lives and to the properties. The purpose of this study is to find out the contribution of other factors such as types of vehicles involved in the road accidents, days of the week in which the accident occurred and the location where the accident happened. Poisson regression was used to model the road accidents in Metro Manila by the help of Statistical Packages for Social Sciences (SPSS). The data were taken from the MMDA from 2008-2013. This study found out that accidents mostly occurred during Fridays at Quezon City and car is the most prone vehicle to road accident.

Keywords: road accident, mathematical modeling, Poisson Regression, SPSS, Metro Manila

INTRODUCTION

A road accident is any activity which distracts the normal trajectory of moving vehicles, in a manner that causes instability of the free flow of the vehicle. It is a global tragedy with the ever-rising trend. It is very common in big cities as there are many modes of transport and roads are narrow and overcrowded. Almost every day, news about accidents were on the television, radio and internet. Most people continue to be negligent and ignore the danger involved in their driving and so, these accidents happen.

In year 2000, road accidents and related injuries alone were the 10th leading cause of death worldwide and were suspected to increase gradually until it will become the 3rd leading cause of disability adjusted life years lost worldwide by 2020 (DOH,2008). Ninety percent of the global road accidents related deaths occur in the middle and low income countries, where 85 percent of the world's population lives.

The biggest burden of road accidents is in South East Asia. Nearly 50 percent road accidents occur in the Asia pacific region (Cal et al., 2005)

According to the road traffic crashes in Metro Manila statistics for the year 2008-2012 by the MMDA, there were 369,114 cases of road accidents for the year 2008-2012. There were a total of 92,324 casualties with 1,799 of them losing their lives, while 90,525 sustained serious injuries.

This reveals that there was an average of one person dying each day which was caused by the road accidents. The most dangerous part of it all is that most people who are killed by the road accidents are those in the age group that constituted the work force of this nation.

Villoria and Diaz (2000) in their study, "Road Accidents in the Philippines" concluded that there is a critical need for the government to address the more fundamental problem of inadequate and inaccurate traffic accident data. Without establishing an effective accident reporting, processing and dissemination system, it would be extremely difficult not only to monitor the level of road traffic safety but also to formulate and implement cost-effective road safety programs. With the rapidly increasing motorization level, indeed the need for attention to and investments in improving road safety is a prime concern.

Pawlus, W. et al. (2002) in their study, "Mathematical Modeling and Analysis of a Vehicle Crash" mentioned that because of the fact that vehicle crash tests are complex and complicated experiments, it is advisable to establish their mathematical models. Their study is an overview of the kinematic and dynamic relationships of a vehicle in a collision. These European researchers presented basic mathematical model representing a collision together with its analysis. Their study determined the methods of establishing parameters of the vehicle crash model and to real crash data investigation. They created a Kelvin model for a real experiment, its analysis and validation. After model's parameters extraction, a quick assessment of an occupant crash severity was done.

With the above mentioned studies , It is imperative to research into road accident data in Metro Manila to come out with the reality on the ground : (1) to fit a model to accident data in the country for better prediction of number of cases in road accidents in order to plan for future occurrence; (2) to create a platform for future studies into road accident and its effects on human lives and properties in Metro Manila; and (3) that policy makers could come out with strategies to reduce the numerous cases caused by road accidents to the barest minimum in the country (Singh,2001).

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The main objective of the study is to develop a mathematical model for road accidents in Metro Manila. This study aimed to determine the day of the year, type of vehicle, and location where the road accidents in Metro Manila are prone in yearly time.

METHODOLOGY

The researchers utilized the descriptive type of research. It revealed the status of road accidents in Metro Manila. Highly specialized software was used such as SPSS (Statistical Package for the Social Sciences).

The study was conducted in Metro Manila (Metropolitan Manila), a metropolitan region composed of the City of Manila and the surrounding cities of Caloocan, Las Piñas, Makati, Malabon, Mandaluyong, Marikina, Muntinlupa, Navotas, Parañaque, Pasay, Pasig, Quezon City, San Juan, Taguig, and Valenzuela, as well as the Municipality of Pateros. Metro Manila is the most populous of the 12 defined metropolitan areas in the Philippines and the 11th most populous in the world. Metro Manila was selected as a study area because the region is the political, economic, social, cultural, and educational center of the Philippines. It was also chosen because it is accessible for the researchers to go back and forth on the said area.

The researchers constructed a letter of request that states the formal request to gather the needed data from MMDA and Philippine National Police-Highway Patrol Group (PNP-HPG). It was also specified in the letter that the data given to the researchers are treated confidential and solely for use in the study. Verification of the said data was done. The data composed of the number of accidents, the date, place, and time the accident happened, as well as the number of fatalities, injured and damaged to property cases.

Methods

The following mathematical and statistical concepts and models were used in this study:

Poisson Regression

In spite of its recent wide application, Poisson regression model remains partly and poorly known, especially if compared with other regression techniques, like linear, logistic and Cox regression models (Oppong, 2012).

The Poisson regression model assumes that the sample of n observations y_i, are observations on independent Poisson variables Y_i with mean u_i .
If this model is correct, the equal variance assumption of classic linear regression is violated, since the Y_i have means equal to their variances.
So one fits the generalized linear model,

log(u_i)= $x_i{}'\beta$

It can be said that the Poisson regression model is a generalized linear model with Poisson error and a log link, so that

$$u_i = \exp(x_i{}'\beta)$$

This implies that one unit increases in an x_i are associated with a multiplication of u_i by $\exp(\beta_i)$.

Assumptions in Poisson Regression

1. Logarithm of the rate changes linearly with equal increment increases in the exposure variable.
2. Changes in the rate from combined effects of different exposures or risk factors are multiplicative.
3. At each level of the covariates the number of cases has variance equal to the mean.
4. Observations are independent.

Methods to identify violations of assumption (3), that is, to determine whether variances are too large or too small include plots of residuals versus the mean at different levels of the predictor variable. Recall that in the case of normal linear regression, diagnostics of the model used plots of residuals against fits (fitted values). This means that the same diagnostics can be used in the case of Poisson Regression (Oppong, 2012).

Parameter Estimation

The parameter estimates table and summarizes the effect of each predictor. While interpretation of the coefficients in this model is difficult because of the nature of the link function, the signs of the coefficients for covariates and relative values of the coefficients for factor levels can give important insights into the effects of the predictors in the model. For covariates, positive (negative) coefficients indicate positive (inverse) relationships between predictors and outcome. An increasing value of a covariate with a positive coefficient corresponds to an increasing rate of damage incidents. For factors, a factor level with a greater coefficient indicates greater incidence of damage. The sign of a coefficient for a factor level is dependent upon that factor level's effect relative to the reference category (Oppong, 2012).

Test of Hypothesis

Likelihood ratio tests for log-linear models can easily be constructed in terms of deviances. In general, the difference in deviances between two nested models has approximately in large samples a chi-squared distribution with degrees of freedom equal to the difference in the number of parameters between the models, under the assumption that the smaller model is correct. One can also use Wald tests, based on the fact that the maximum likelihood estimator $\hat{\beta}$ has approximately in large samples a multivariate normal distribution with mean equal to the true parameter value β and variance-covariance matrix, $var(\hat{\beta}) = X'WX$ where X is the model matrix and W is the diagonal matrix of estimation weights.

Goodness Fit of Test

The goodness-of-fit statistics table provides measures that are useful for comparing competing models. Additionally, the Value/df for the Deviance and Pearson Chi-Square statistics gives corresponding estimates for the scale parameter. These values should be near 1.0 for a Poisson regression; the fact that they are greater than 1.0 indicates that fitting the over dispersed model may be reasonable.

Omnibus Test

The omnibus test is a likelihood-ratio chi-square test of the current model versus the null (in this case, intercept) model. The significance value of less than 0.05 indicates that the current model outperforms the null model.

Akaike Information Criterion (AIC)

The Akaike information criterion (AIC) is a measure of the relative quality of a statistical model, for a given set of data. As such, AIC provides a means for model selection.

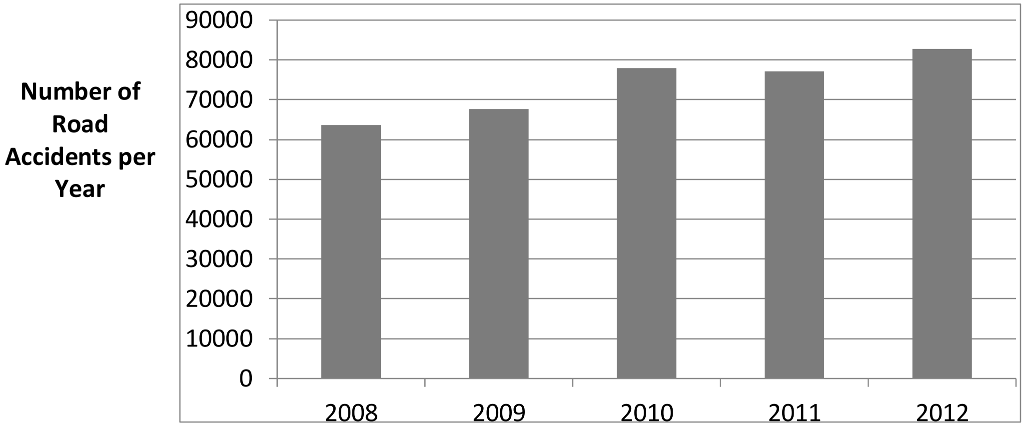
AIC deals with the trade-off between the goodness of fit of the model and the complexity of the model. It is founded on information entropy: it offers a relative estimate of the information lost when a given model is used to represent the process that generates the data (Oppong, 2012).

RESULTS AND DISCUSSION

The Number of Road accidents in Metro Manila

There were 369,114 road accidents which occurred in Metro Manila from January 2008 to December 2012. This shows that on the average, 73,883 road accidents occurred every year in Metro Manila.

Graph 1 shows the time in years for which road accidents occurred. It also shows the total number of road accidents annually from 2008-2012.

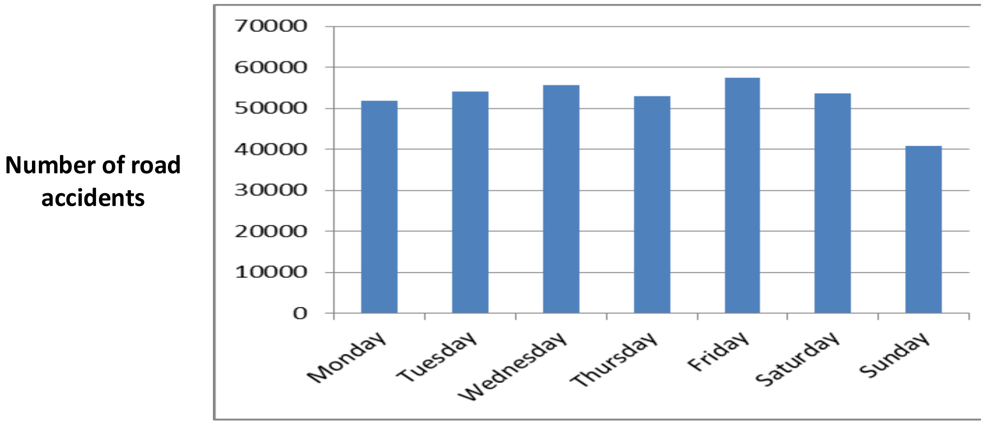


Graph 1. A bar graph illustrating the number of road accidents in Metro Manila from January 1, 2008 to December 31, 2012

Clearly, the chart shows that from year 2008, the number of road accidents is ascending as it reaches the year of 2012. Several factors may affect the increase and decrease of the number of road accidents in Metro Manila like days in the week, the type of vehicle involved and the location/city in Metro Manila.

The Days on which Road Accidents Happened

The number of road accidents occurred in each day of the week is presented in graph 2. It also contains the percentage number of road accidents in each day for the five year period and arithmetic means of the number of road accidents in each day for every year for the five years.



Graph2. A bar graph illustrating the number of road accidents per day in Metro Manila from January 1, 2008 to December 31, 2012

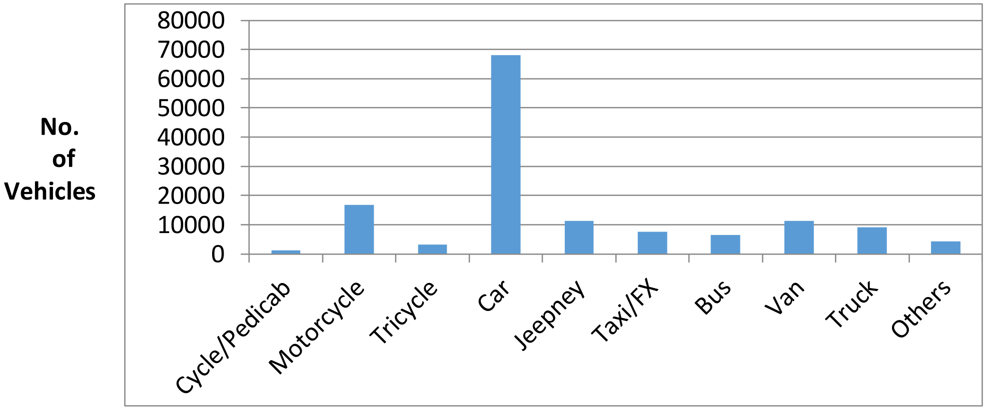
It can be seen in Graph 2 that Friday has the highest number of road accidents from 2008-2012 in Metro Manila. There were 57,561 road accidents which constitute 15.71% of the total number of road accidents. Next is Wednesday which had 55,550 accidents and constitute 15.16 % of road accidents. Followed by Tuesday that has 54,176 road accidents occurred with 14.78%. Saturday has 14.61% of road accidents with 53,549 accidents. While Thursday recorded 52,949 road accidents with a percentage of 14.45. On Mondays, 51,771 road accidents happened with 14.13% and Sunday has 40,896 road accidents with 11.16%.

Type of Vehicle Involved in Road Accidents in Metro Manila

The type of vehicle involved in road accident cannot be ruled out as a contributory factor to the number of accidents. The type of vehicle involved in the road accident, the number of accidents by the type of vehicle, the percentage number of road accidents and the average number of road accidents by type of vehicle for every year are presented in graph 3.

Number of road accidents through different types of vehicle in Metro Manila from 2008-2012

From Graph 3 it could be seen that cars engaged in road accidents with 340,356 involved from 2008 to 2010 constitute 48.7529 % of the total number of road accidents in the same period.

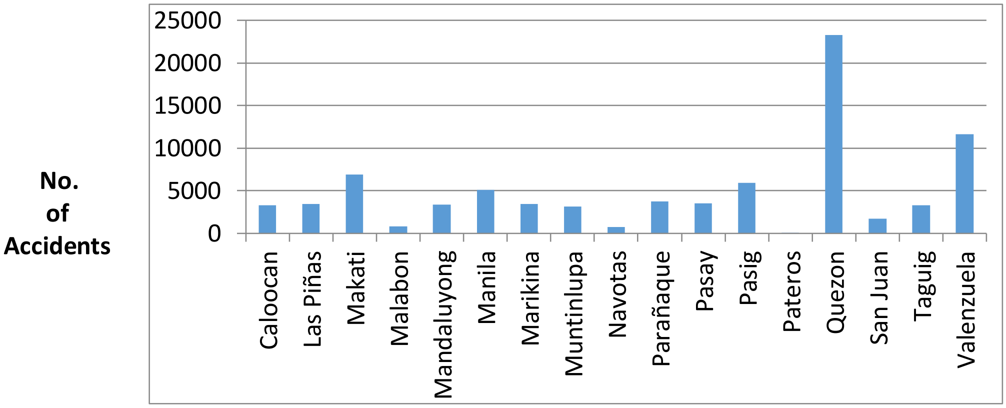


Graph 3. A bar chart showing the average number of vehicles involved in road accidents in Metro Manila from 2008-2012

The chart shows clearly that cars, motorcycle and van are the three major vehicle types involved in road accidents in Metro Manila. Cars and motorcycles are two of the highest registered vehicles in the Philippines. And so clearly, Figure 4 shows the number of registered vehicles/ used vehicles in Metro Manila, which affect the number of road accidents in Metro Manila.

Number of city road accidents in Metro Manila from 2008-2012

The place where the road accidents mostly occurred is in Quezon City having 31.36% of the total number of road accidents from 2008-2012. Pateros having 0.106 % of the total number of road accidents is considered to have the least among the cities.



Graph 4. A bar chart showing the average number of road accidents by the city in Metro Manila from 2008-2012

The chart clearly illustrates that Quezon City, Valenzuela City and Makati City are the three major cities where road accidents happened within the vicinity in Metro Manila. This implies that if a city has a larger number of major roads, these may influence the number of road accidents in Metro Manila. Quezon City, has many major roads including Commonwealth Ave., and Balete Drive which are known to be the killer highways.

Modeling the Number of Road Accidents in Metro Manila

In order to model the number of road accidents in Metro Manila, SPSS statistical package version 19.0 was used. The Generalized Linear Model (GLM) procedure with Poisson as the main distribution specified using the Log Link function.

The various models were obtained when number of road accidents was regressed on factors such as the day the accident occurred, the type of vehicle which was involved in the accident, and the place/city in Metro Manila where the accident happened.

The Days in which Road Accidents Happened

The days in which road accidents happened from 2008 to 2012 was modeled using Poisson regression and the various models with their AIC's presented in table 1.

Table 1
The Poisson Regression Models for the Number of Road Accidents in the Days of the Week with their AIC's

Models	AIC's
1. $log\ (mean\_accident) = \beta_0 + \beta_i Day,$ $i = 1,2,3, \dots 7$	3858.258
2. $log(mean\_accident) = \beta_0 + \beta_i Year,$ $i = 1,2,3, \dots 5$	4165.404
3. $log(mean\_accident) = \beta_0 + \beta_i Day + \beta_j Year,$ $i = 1,2,3, \dots 7,$ $j = 1,2,3, \dots 8$	667.938

The table shows that the best model which fit the number of road accidents in the days of the week from 2008-2012 in Metro Manila is model 3 because it has 667.938 which are the smallest AIC. Further, it has deviance of 257.989 on 24 degrees of freedom, scaled deviance of 257.989 on 24 degrees of freedom, Pearson Chi-Square of 256.207 on 24 degrees of freedom, and scaled Pearson chi-square of 256.207 on 24 degrees of freedom. The AIC's of model 1 and 2 are 3858.258 and 4165.404 respectively. These do not represent a good model. The parameters with their corresponding estimates are shown in the table 2, containing the standard error, Wald Chi-Square with their estimated Poisson regression coefficients.

Table 2
The Parameter Estimates of Selected Poisson Model for the number of road accidents in the Days of Week from 2008 to 2010 in Metro Manila
Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval Lower	Upper	Hypothesis Test Wald Chi-Square	df	Sig.
(Intercept)	9.121	.0058	9.110	9.133	2452353.936	1	.000
[year=1.00]	-.259	.0053	-.270	-.249	2397.602	1	.000
[year=2.00]	-.191	.0052	-.201	-.181	1355.413	1	.000
[year=3.00]	-.070	.0050	-.080	-.060	192.217	1	.000
[year=4.00]	-.061	.0050	-.071	-.051	147.769	1	.000
[year=5.00]	0[a]	.	.	.	.	.	.
[day=1.00]	.236	.0066	.223	.249	1270.346	1	.000
[day=2.00]	.281	.0066	.268	.294	1842.823	1	.000
[day=3.00]	.306	.0065	.293	.319	2209.207	1	.000
[day=4.00]	.258	.0066	.245	.271	1539.451	1	.000
[day=5.00]	.342	.0065	.329	.354	2793.442	1	.000
[day=6.00]	.270	.0066	.257	.282	1684.922	1	.000
[day=7.00]	0[a]	.	.	.	.	.	.
(Scale)	1[b]						

Table 2 shows the parameter estimates of the selected model. The AIC of this model is 667.938; deviance of 257.989 on 24 degrees of freedom, scaled deviance of 257.989 on 24 degrees of freedom, Pearson Chi-Square of 256.207 on 24 degrees of freedom, and scaled Pearson chi-square of 256.207 on 24 degrees of freedom. The coefficient for day=1.00 which is Monday was found to be 0.236 and a 0.000 significant difference at 5% α-level ,which indicates that it is significant in explaining the model. Same thing with the significant difference of day=2.00 (Tuesday), day=3.00 (Wednesday), day=4.00 (Thursday), day=5.00 (Friday), day=6.00 (Saturday) and day=7.00 (Sunday) are all 0.000, which shows that all of the variables are highly significant in explaining the model at 5% α-level.

Type of Vehicle involved in the Accident

The number of road accidents by different type of vehicles was modeled using Poisson Regression and the results are presented in table 3. The table contains various models generated and their AIC's.

Table 3
The Poisson Regression Models for Number of Road Accidents through Different Types of Vehicle from 2008 to 2012 with their AIC's

Models	AIC's
1. $log\ (mean\_accident) = \alpha_1 + \beta_i VEhicleType,$ $i = 1,2,3, \dots 8$	12267.485
2 . $log(mean\_accident) = \alpha_2 + \beta_i Year,$ $i = 1,2,3, \dots 5$	804456.513
3. $log(mean\_accident) = \alpha_1 + \beta_i VEhicleType + \alpha_2 + \beta_j Year,$ $i = 1,2,3, \dots 5,$ $j = 1,2,3, \dots 8$	5976.832

Table 3 shows that the best model which fits the type of vehicle involved in the accidents from 2008-2012 in Metro Manila is model 3 because it has 5976.832 which is the smallest AIC. The AIC's of model 1 and 2 are 12267.485 and 804456.513 respectively which do not represent a good model. The parameters with their corresponding estimates as shown in Table 4, contain the standard error, Wald Chi-Square with their estimated Poisson regression coefficients.

Table 4
The Parameter Estimates of Selected Poisson Model for the number of road accidents by Different Types of Vehicle from 2008 to 2010 in Metro Manila
Parameter Estimates

Parameter		Std.	95% Wald Confidence Interval		Hypothesis Test		
	B	Error	Lower	Upper	Wald Chi-Square	Df	Sig.
(Intercept)	8.484	.0072	8.470	8.498	1406051.346	1	.000
[YEAR=1.00]	-.255	.0038	-.262	-.247	4414.265	1	.000
[YEAR=2.00]	-.201	.0038	-.209	-.194	2842.048	1	.000
[YEAR=3.00]	-.055	.0036	-.062	-.048	229.029	1	.000
[YEAR=4.00]	-.065	.0036	-.072	-.058	319.392	1	.000
[YEAR=5.00]	0[a]	.	.	.	.	.	.
[VEHICLE=1.00]	-1.254	.0144	-1.283	-1.226	7558.262	1	.000
[VEHICLE=2.00]	1.355	.0076	1.341	1.370	31612.779	1	.000
[VEHICLE=3.00]	-.268	.0103	-.288	-.248	673.999	1	.000
[VEHICLE=4.00]	2.755	.0070	2.741	2.769	154464.976	1	.000
[VEHICLE=5.00]	.954	.0080	.938	.969	14205.491	1	.000
[VEHICLE=6.00]	.572	.0085	.555	.588	4522.449	1	.000
[VEHICLE=7.00]	.409	.0088	.392	.427	2179.149	1	.000
[VEHICLE=8.00]	.965	.0080	.949	.980	14579.974	1	.000
[VEHICLE=9.00]	.745	.0083	.729	.761	8145.844	1	.000
[VEHICLE=10.00]	0[a]	.	.	.	.	.	.
(Scale)	1[b]						

Table 4 shows the parameter estimates of the selected model. The AIC of this model is 5976.832; deviance of 5408.157 on 36 degrees of freedom, scaled deviance of 5408.157 on 36 degrees of freedom, Pearson Chi-Square of 5298.370 on 36 degrees of freedom, and scaled Pearson chi-square of 5298.370 on 36 degrees of freedom. The coefficient for vehicle=1.00 which is cycle/pedicab was found to be -1.254 which means that the expected log count for vehicle=1.00 decreases by about 1.254, with a 0.000 significant difference at 5% α-level ,which indicates that is significant in explaining the model. Same thing with the significant difference of vehicle=2.00 (motorcycle), vehicle=3.00 (tricycle), vehicle=4.00 (car), vehicle=5.00 (jeepney), vehicle=6.00 (taxi/fx), vehicle=7.00 (bus), vehicle=8.00 (van), vehicle=9.00 (truck), and vehicle=10.00 (others) are all 0.000, which shows that all of the variables are significant in explaining the model at 5% α-level.

The City in Metro Manila where Road Accidents Occurred from 2008-2012

The city in Metro Manila where road accidents occurred was modeled using Poisson Regression and the results are presented in the table 5 below. The table contains various models generated and their AIC's.

Table 5
The Poisson Regression Models for Number of Road Accidents through Year and City from 2008 to 2012 with their AIC's

Models	AIC's
1. $log\ (mean\_accident) = \alpha_1 + \beta_i City,$ $i = 1,2,3,\ldots 8$	8807.189
2 . $log(mean\_accident) = \alpha_2 + \beta_i Year,$ $i = 1,2,3,\ldots 5$	325213.163
3. $log(mean\_accident) = \alpha_1 + \beta_i City + \alpha_2 + \beta_j Year,$ $i = 1,2,3,\ldots 5,$ $j = 1,2,3,\ldots 8$	5053.236

Table 5 shows that the best model which fit the type of vehicle involved in the accidents from 2008-2012 in Metro Manila is model 3 because it has 5053.236 which is the smallest AIC. Moreover, it has deviance of 7948.212 on 68 degrees of freedom, scaled deviance of 7948.212 on 68 degrees of freedom, Pearson Chi-Square of 8141.558 on 68 degrees of freedom, and scaled Pearson chi-square of 8141.558 on 24 degrees of freedom. The AIC's of model 1 and 2 are 8807.189 and 5053.236 respectively which do not represent a good model. The parameters with their corresponding estimates are shown in the table 6; it contains the standard error, Wald Chi-Square with their estimated Poisson regression coefficients.

Table 6
The Parameter Estimates of Selected Poisson Model for the number of road accidents by City in Metro Manila from 2008 to 2010 in Metro Manila
Parameter Estimates

Parameter		Std.	95% Wald Confidence Interval		Hypothesis Test		
	B	Error	Lower	Upper	Wald Chi-Square	Df	Sig.
(Intercept)	7.858	.0098	7.839	7.878	646966.441	1	.000
[year=2008.00]	-.263	.0053	-.274	-.253	2491.414	1	.000
[year=2009.00]	-.201	.0052	-.211	-.191	1502.821	1	.000
[year=2010.00]	-.028	.0050	-.037	-.018	30.978	1	.000
[year=2011.00]	-.071	.0050	-.080	-.061	199.387	1	.000
[year=2012.00]	0[a]	.	.	.	.	.	.
[city=1.00]	.361	.0121	.337	.384	890.473	1	.000
[city=2.00]	.405	.0120	.381	.428	1141.305	1	.000
[city=3.00]	1.086	.0107	1.065	1.107	10241.502	1	.000
[city=4.00]	-1.073	.0184	-1.109	-1.037	3410.055	1	.000
[city=5.00]	.369	.0121	.346	.393	936.762	1	.000
[city=6.00]	.784	.0112	.762	.806	4904.975	1	.000
[city=7.00]	.399	.0120	.376	.423	1109.959	1	.000
[city=8.00]	.306	.0122	.282	.330	627.238	1	.000
[city=9.00]	-1.131	.0188	-1.168	-1.094	3627.308	1	.000
[city=10.00]	.488	.0118	.465	.511	1716.859	1	.000
[city=11.00]	.415	.0120	.392	.439	1206.762	1	.000
[city=12.00]	.939	.0109	.917	.960	7360.605	1	.000
[city=13.00]	-3.384	.0512	-3.485	-3.284	4364.247	1	.000
[city=14.00]	2.306	.0097	2.287	2.325	56184.759	1	.000
[city=15.00]	-.275	.0141	-.303	-.248	380.564	1	.000
[city=16.00]	.346	.0121	.322	.370	813.545	1	.000
[city=17.00]	0[a]	.	.	.	.	.	.
(Scale)	1[b]						

Table 6 shows the parameter estimates of the selected model. The AIC of this model is 5053.236; deviance of 4186.258 on 64 degrees of freedom, scaled deviance of 4186.258 on 64 degrees of freedom, Pearson Chi-Square of 4355.66 on 64 degrees of freedom, and scaled Pearson chi-square of 4355.66 on 64 degrees of freedom. The coefficient for city=1.00 which is Caloocan was found to be 0.361 with a 0.000 significant difference at 5% α-level ,which indicates that is significant in explaining the model. Same thing with the significant difference of city=2.00 (Las Piñas), city=3.00 (Makati), city =4.00 (Malabon), city =5.00 (Mandaluyong), city=6.00 (Manila), city=7.00 (Marikina), city=8.00 (Muntinlupa), city=9.00 (Navotas), city=10.00 (Parañaque), city=11.00 (Pasay), city=12.00 (Pasig) city=13.00 (Pateros), city=14.00 (Quezon), city=15.00 (San Juan), city=16.00 (Taguig), and city=17.00 (Valenzuela) are all 0.000, which shows that all of the variables are significant in explaining the model at 5% α-level.

CONCLUSIONS

With the Poisson Regression Models, the best model which fits the number of road accidents in the days of the week from 2008-2012 in Metro Manila is model 3 because it has 667.938

$$log(mean\_accident) = \beta_0 + \beta_i Day + \beta_j Year,$$
$$i = 1,2,3, \dots 7,$$
$$j = 1,2,3, \dots 8$$

The best model which fits the type of vehicle involved in the accidents from 2008-2012 in Metro Manila is model 3 because it has 5976.832 which is the smallest AIC.

$$log(mean\_accident) = \alpha_1 + \beta_i VEhicleType + \alpha_2 + \beta_j Year,$$
$$i = 1,2,3, \dots 5,$$
$$j = 1,2,3, \dots 8$$

The best model which fits the type of vehicle involved in the accidents from 2008-2012 in Metro Manila is model 3 because it has 5053.236

$$log(mean\_accident) = \alpha_1 + \beta_i City + \alpha_2 + \beta_j Year,$$
$$i = 1,2,3, \dots 5,$$
$$j = 1,2,3, \dots 8$$

Among the days of the week, Friday has the highest chance of having a road accident which has road accidents between 1.3896 and 1.4248 with 95% confidence. Friday is typically the last day of regular working days in a week. Also, cars have the highest chance of engaging in a road accident between 15.5024 and 15.9427 with 95% confidence. Similarly, Quezon City has the highest probability of engaging in a road accident between 9.845357261 and 10.22668009 with 95% confidence.

The researchers conclude that the day the road accidents mostly occur is on Friday because a huge number of vehicles move in and out the Metro Manila areas. Moreover, car is the most prone vehicle engaging road accident for the reason that it is the widely held vehicle passing through the city. Furthermore, Quezon City is the place where accidents mostly occur because it has the biggest land area among the cities in Metro Manila.

RECOMMENDATIONS

It is recommended that education on road accidents should be intensified among the drivers, passengers, and pedestrian. Since the type of vehicle involved in the accident affects the number of road accidents, drivers of vehicle should be given special training to be able to avoid preventable accidents. The institutions that enforce road traffic regulation should do well to apply the law especially on Friday. The fact that the vehicle mainly involved in the accident is car, it is advised that more regulations must be implemented.

Further studies should be conducted comparing assessment of Poisson and Negative Binomial Regressions or other models as verification for road count data.

For better accuracy, the researchers recommend that future studies be conducted and include more variables so that researchers could really determine the actual factors contributing to the number of road accidents.

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